

## SENSOR APPARATUS SYSTEMS, DEVICES AND METHODS

### CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is a continuation of U.S. patent application Ser. No. 16/112,375, filed Aug. 24, 2018 and issued as U.S. Pat. No. 10,697,913 on Jun. 30, 2020, which is a continuation of U.S. patent application Ser. No. 15/393,994, filed Dec. 29, 2016 and issued as U.S. Pat. No. 10,060,867 on Aug. 28, 2018, and entitled Sensor Apparatus Systems, Devices and Methods, which is a continuation of U.S. patent application Ser. No. 14/672,764, filed Mar. 30, 2015 and issued as U.S. Pat. No. 9,535,021 on Jan. 3, 2017, and entitled Sensor Apparatus Systems, Devices and Methods, which is a continuation of U.S. patent application Ser. No. 13/619,266, filed Sep. 14, 2012 and issued as U.S. Pat. No. 8,992,075 on Mar. 31, 2015, and entitled Sensor Apparatus Systems, Devices and Methods, which is a continuation of U.S. patent application Ser. No. 12/038,474, filed Feb. 27, 2008 and issued as U.S. Pat. No. 8,491,184 on Jul. 23, 2013, and entitled Sensor Apparatus Systems, Devices and Methods, which is a continuation-in-part of patent application Ser. No. 11/871,821, filed Oct. 12, 2007, now abandoned, and entitled Sensor Apparatus Systems, Devices and Methods, which claims priority from the following United States Provisional patent applications, all of which are hereby incorporated herein by reference in their entireties:

**[0002]** U.S. Provisional Patent Application No. 60/904,024 entitled Hemodialysis System and Methods filed on Feb. 27, 2007; and

**[0003]** U.S. Provisional Patent Application No. 60/921,314 entitled Sensor Apparatus filed on Apr. 2, 2007.

**[0004]** This application is also related to the following United States patent applications, which are hereby incorporated herein by reference in their entireties:

U.S. patent application Ser. No. 11/871,712, filed Oct. 12, 2007 and issued as U.S. Pat. No. 8,317,492 on Nov. 27, 2012, entitled Pumping Cassette; U.S. patent application Ser. No. 11/871,787, filed Oct. 12, 2007 and entitled Pumping Cassette; U.S. patent application Ser. No. 11/871,793, filed Oct. 12, 2007 and issued as U.S. Pat. No. 8,888,470 on Nov. 18, 2014, and entitled Pumping Cassette; U.S. patent application Ser. No. 11/871,803, filed Oct. 12, 2007 and issued as U.S. Pat. No. 7,967,022 on Jun. 28, 2011 and entitled Cassette System Integrated Apparatus; U.S. patent application Ser. No. 11/871,828, filed Oct. 12, 2007 and issued as U.S. Pat. No. 8,366,655 on Feb. 5, 2013, and entitled Peritoneal Dialysis Sensor Apparatus, Systems, Devices and Methods; U.S. patent application Ser. No. 12/038,648, filed Feb. 27, 2008 and issued as U.S. Pat. No. 8,042,563 on Oct. 25, 2011 and entitled Cassette System Integrated Apparatus; and U.S. patent application Ser. No. 12/072,908, filed Feb. 27, 2008 and issued as U.S. Pat. No. 8,246,286 on Aug. 21, 2012 and entitled Hemodialysis System and Methods.

### TECHNICAL FIELD

**[0005]** The present invention relates to sensor systems, devices, and methods, and more particularly to systems, devices, and methods for sensors, sensor apparatus, and sensor apparatus systems.

### BACKGROUND ART

**[0006]** In many applications, the temperature of a media, whether a solid, liquid or gas, is determined. One method is introducing a temperature sensor apparatus or probe to the medium being measured. For accuracy, close proximity of the sensor to the subject media is desired. However, this method may lead to contamination of the sensor apparatus and/or the fluid. Additional problems with harsh media or problems with the accuracy of the device used exist.

**[0007]** The concentration of a known compound in a media, whether fluid or otherwise, can be determined through measuring the conductivity of the fluid. Determining the conductivity of a material can also provide useful information such as the composition or presence of a particular compound in a material or irregularities in the conductive material between conductivity sensing probes. The presence, absence or variation of conductivity can also be a useful determinant of anomalies in a system.

**[0008]** There is a need for an apparatus that can both sense the temperature and the conductivity of a fluid or other media. There is a desire for a combination temperature and conductivity sensor that avoid contamination with the subject media and is compact. Also, there is a desire for an accurate temperature sensing device.

**[0009]** Additionally, there is a need for an accurate measurement apparatus to measure the temperature, conductivity, and/or other condition of a subject media while avoiding contamination between with the measurement apparatus and the subject media. There is also a need for an accurate measurement apparatus that can measure the temperature, conductivity, and/or other condition of a subject media where such subject media is contained in and/or flowing through a disposable component such that part or all of the sensor apparatus can be reused and need not be disposed of along with the disposable component.

### SUMMARY OF THE INVENTION

**[0010]** In accordance with one aspect of the invention there is provided a sensor apparatus system for determining one or more properties of a subject fluid in a cassette, the system comprising a probe housing; a thermal sensor in said probe housing having a sensing end and a connector end; a probe tip thermally coupled to said sensing end of the thermal sensor and attached to said probe housing, the probe tip adapted for thermal coupling with an inner surface of a well installed in a cassette; and at least two leads connected to said connector end of said thermal sensor, whereby thermal energy is transferred from said well to said thermal sensor and whereby temperature information is conveyed through said leads. In various alternative embodiments, the sensing probe may further include a third lead attached to one of the probe housing, the thermal sensor, and the probe tip for permitting conductivity sensing. Alternatively, the sensing probe may further include a conductivity sensor attached to one of the probe housing, the thermal sensor, and the probe tip for permitting conductivity sensing; and a third lead attached to the conductivity sensor for transmitting conductivity information. A urethane resin may be included between said probe tip and said probe housing. The probe tip may include a flange for mating with the housing.

**[0011]** In various alternative embodiments of the sensor apparatus system described above, thermal epoxy may be included between said thermal sensor and said probe tip. The